What are the health effects related to consumption of chocolate?

Conclusion

Moderate evidence suggests that modest consumption of dark chocolate or cocoa is associated with health benefits in the form of reduced cardiovascular disease risk. Potential health benefits need to be balanced with caloric intake.

Grade: Moderate
Overall strength of the available supporting evidence: Strong; Moderate; Limited; Expert Opinion Only; Grade not assignable For additional information regarding how to interpret grades, click here.

Executive Summary Overview

The current evidence regarding chocolate and health outcomes primarily focuses on flavonoids as bioactive constituents of chocolate and their relation to cardiovascular disease (CVD) risk. Flavonoids are a subgroup of polyphenols, and within the flavonoid chemical hierarchy the flavan-3-ols (flavanols) are particularly high in dark chocolate and cocoa. The flavan-3-ols in dark chocolate and cocoa are primarily catechins, epicatechins (monomers) and procyanidins (polymers).

A Nutrition Evidence Library (NEL) search of the literature since 2000 identified a total of 13 studies that addressed the question on health effects of chocolate consumption. Three methodologically strong systematic reviews of international randomized controlled trials (RCTs) and prospective cohort studies (Desch, 2010; Ding, 2006; Hooper, 2008) were identified. Eight RCTs conducted in the US, Europe, Australia and Japan, covering from 25 to 297 subjects, that were methodologically strong (Allen, 2008) and methodologically neutral (Baba, 2007; Crews, 2008; Davidson, 2008; Farouque, 2006; Kurlandsky and Stote, 2006; Monagas, 2009; Tuabert, 2007) were identified. One methodologically strong prospective cohort study of 876 males in the Netherlands (Buijsse, 2006) and one methodologically neutral population-based case-control study conducted in Sweden (Janszky, 2009) were included to address this question.

The systematic review and meta-analysis by Desch et al (2010) covered 10 randomized controlled trials and showed that high-flavanol chocolate or cocoa significantly lowered systolic blood pressure (SBP) and diastolic blood pressure (DBP) (Desch, 2010). Hooper et al (2008) included six RCTs in their meta-analysis and showed that dark chocolate or cocoa improved flow mediated dilation both acutely and chronically. Ding et al (2006) included 21 RCTs and 11 prospective cohort studies and both flavonoids and stearic acid were examined for association with intermediate markers and CVD outcomes. Overall, the RCTs suggested that cocoa and chocolate have beneficial effects on blood pressure (BP), inflammatory markers, anti-platelet function, serum high-density lipoprotein (HDL) and low-density lipoprotein (LDL) oxidation. The prospective cohort studies showed that flavonoids in chocolate were positively associated with decreased risk of CHD and myocardial infarction (MI) mortality. Overall, the evidence from these systematic reviews and meta-analyses was strengthened by the consistency of findings across studies.

The RCTs in this evidence analysis were focused on flavonoids and intermediate markers of CVD risk. Studies showed that dark chocolate or cocoa consumption decreased serum total cholesterol (TC) and LDL-C, increased HDL-C, delayed LDL oxidation (Baba, 2007), decreased serum triglycerides (TG) and improved inflammation markers (Kurlandsky and Stote, 2006). However, one study found no effect of dark chocolate consumption on serum cholesterol levels (Kurlandsky and Stote, 2006). Regarding BP, dark chocolate or cocoa consumption decreased SBP (Allen, 2008; Tuabert, 2007), DBP (Davidson, 2008) and decreased prevalence of hypertension (HTN) (Tuabert, 2007). One RCT found no effect of dark chocolate or cocoa consumption on BP (Crews, 2008). A more detailed analysis of inflammation markers showed that cocoa consumption decreased monocyte expression of numerous cell adhesion molecules (Monagas, 2009). Additionally, high-flavonol cocoa (vs. low flavonol cocoa) increased flow-mediated dilation, both acutely and chronically and reduced insulin resistance (Davidson, 2008). High-flavonol cocoa was also tested in subjects with coronary artery disease (CAD) and did not improve any markers of arterial blood flow or inflammation (Farouque, 2006).

The evidence regarding chocolate and CVD health outcomes contains relatively few epidemiologic studies. Overall, this evidence included populations in the US, Europe, Japan and Australia, participating in both primary prevention and, to a lesser extent, secondary prevention studies. Subject sample sizes ranged from relatively small randomized controlled trials to 470 subjects in the Zutphen Elderly Study and 1,169 subjects in the SHEEP study.

A prospective cohort study in the Netherlands examined cocoa intake and found it inversely associated with BP and CVD mortality in male subjects from the Zutphen Elderly Study (Buijsse, 2006). A population-based case-control study assessed the effects of chocolate consumption in patients with established CHD in the Stockholm Heart Epidemiology Program (SHEEP) where people who had had MIs were followed for eight years. In this study, chocolate consumption had a significant inverse association with cardiac mortality (Janszky, 2009).

Evidence Summary Paragraphs

Systematic Reviews/Meta-analyses

Desch et al, 2010 (positive) This was systematic review with meta-analysis covering 10 selected RCTs with 297 subjects to investigate the effects of cocoa products (dark chocolate and cocoa beverages) on BP, due to their high content of flavanols. Subjects were healthy adults or with pre-hypertension (PHTN) and treatment duration ranged from two to 18 weeks. The mean BP change across all trials was -4.5mmHg (95% CI: -5.9 to -3.2, P<0.001) for SBP and -2.5mmHg (95% CI: -3.9 to -1.2, P<0.001) for DBP. The meta-analysis confirms the BP-lowering effects of flavanol-rich cocoa products in a larger, updated set of trials than previously reported. Limitations included statistical heterogeneity across studies.

Ding et al, 2006 (positive) This was a systematic review that covered MEDLINE publications from 1966 to 2005 on experimental, observational and clinical studies of the association between cocoa, cacao, chocolate, stearic acid, flavonoids and risk of CVD (CHD and stroke). In addition, an updated meta-analysis was done on flavonoid intake and CHD mortality. Overall, RCTs measured intermediate markers of CVD risk and showed cocoa and chocolate have beneficial effects by lowering blood pressure, decreasing inflammation markers, increasing HDL and decreasing LDL oxidation. Stearic acid, on the other hand, did not affect serum cholesterol and lipoprotein levels. Epidemiological studies on the association of stearic acid and CVD risk were considered inconclusive with methodological limitation. There was a large body of prospective cohort studies on flavonoids that showed chocolate reduced risk of CVD mortality. The updated meta-analysis indicated that intake of flavonoids lowered risk of CHD mortality, RR=0.81 (95% CI: 0.71 to 0.92) comparing highest and lowest tertiles.

Hooper et al, 2008 (positive) This was a meta-analysis of RCTs on flavonoid-rich foods and CVD risk. For the purposes of question 5.3 on chocolate, the meta-analysis of the effects of chocolate or cocoa on the percentage of FMD is relevant (Figure 3). The authors showed that chocolate increased FMD after acute (3.99%; 95% CI: 2.86%, 5.12%) and chronic (1.45%; 0.62%, 2.28%) intake. The time-course suggested a peak effect at approximately two hours, but subgrouping by epicatechin dose did not suggest a strong epicatechin dose effect. The authors note

that more studies of the effects of chronic intake are necessary to confirm a clinically significant effect on FMD.

Primary Articles

Allen et al, 2008 (positive) This was a randomized crossover trial conducted in the US to examine the effect of daily consumption of a flavanol-containing chocolate bar with added phytosterols on cardiovascular risk factors in normotensive subjects with elevated cholesterol. After a two-week lead-in diet based on the American Heart Association (AHA) "An Eating Plan for Healthy Americans," subjects consumed two cocoa flavanol-containing dark chocolate bars per day, with or without 1.1g sterol esters per bar, for a period of four weeks and then were switched to the other chocolate bar for an additional four weeks. Out of 650 recruited subjects, 49 entered the study, and 44 subjects completed the study, 24 initially receiving the phytosterol-containing bars (66% male, mean age 45.9±8.1 years) and 20 initially receiving the control bars (64% male, mean age 43.5±8.9 years). Regular consumption of the phytosterol-containing chocolate bars resulted in reductions of 2.0% in serum TC and 5.3% in LDL-C (both $P<0.05$). In addition, consumption of cocoa flavanols reduced SBP after eight weeks (-5.8mmHg, $P<0.05$). Limitations include the lack of a washout period between interventions, as well as the lack of comparison to diet-only controls. Baseline comparison with flavonol-containing dark chocolate bar.

Baba et al, 2007 (neutral) This was an RCT conducted in Japan to test whether long-term intake of cocoa powder altered plasma lipid profiles in normocholesterolemic and mildly hypercholesterolemic human subjects. Twenty-five male subjects (mean age 38±1 years) were randomized to consume either 12g sugar a day (control group) or 26g cocoa powder and 12g sugar a day (cocoa group) for 12 weeks; all 25 completed the trial. Plasma HDL-C was significantly increased in the cocoa group compared with the control group (24% vs. 5%, $P<0.05$). In addition, the prolongation from baseline levels in the lag time of LDL oxidation in the cocoa group was significantly greater than the reduction measured in the control group (9% vs. -13%, $P<0.05$). Limitations include the small sample size consisting of only male subjects, limiting generalizability.

Buijsse et al, 2006 (positive) This was a cohort study conducted in the Netherlands to examine whether habitual cocoa intake was inversely related to BP and cardiovascular mortality in elderly male participants from the Zutphen Elderly Study. Cocoa intake was estimated in 1985, 1990 and 1995 by dietitians through the cross-check dietary history; causes of death were ascertained during 15 years of follow-up. Out of 876 men (aged 65 to 84 years at baseline) with dietary intake estimations, chronic disease prevalence was available for 790 men; 470 were included in the analysis. During the 15-year follow-up, 314 men died (66.8%), 152 from CVD. Median cocoa intake was 2.11g per day in 1985, 2.30g per day in 1990 and 2.36g per day in 1995. After multivariate adjustment, compared to the lowest tertile of cocoa intake, the mean SBP in the highest tertile of cocoa intake was 3.7 mmHg lower (95% CI: -7.1 to -0.3mmHg, $P=0.03$) and the mean DBP was 2.1mmHg lower (95% CI: -4.0 to -0.2mmHg, $P=0.03$). Compared with the lowest tertile of cocoa intake, the adjusted relative risk (RR) for men in the highest tertile of cocoa intake was 0.50 (95% CI: 0.32 to 0.78, $P=0.004$) for cardiovascular mortality and 0.53 (95% CI: 0.39 to 0.72, $P<0.001$) for all-cause mortality. No limitations were noted.

Crews et al, 2008 (neutral) This was an RCT conducted in the US to examine the short-term effects of dark chocolate and cocoa on variables associated with neuropsychological functioning and cardiovascular health in healthy, cognitively intact older adults. Participants were randomly assigned to receive a 37g dark chocolate bar and 237ml of an artificially sweetened cocoa beverage, or similar placebo products, each day for six weeks. Of 101 subjects aged 60 years or older initially randomized, 90 completed the trial (38 males and 52 females), 45 in each group. No significant (NS) group-by-trial interactions were found for any of the neuropsychological variables, hematologic tests or BP variables examined. However, the mean pulse rate after three and six weeks of treatment was significantly higher in the dark chocolate and cocoa group than at baseline ($P<0.01$) and when compared with the placebo group at three and six weeks ($P<0.01$). Authors note the relatively short duration of the treatment phase and the small quantity of dark chocolate and cocoa may have contributed to the null findings.

Davison et al, 2008 (neutral) This was an RCT conducted in Australia to investigate the effect of cocoa flavanols and exercise on cardio-metabolic risk factors in overweight and obese subjects. Subjects were randomized to one of four groups for 12 weeks: High-flavanol cocoa (902mg flavanols), high-flavanol cocoa and exercise, low-flavanol cocoa (36mg flavanols) or low-flavanol cocoa and exercise; exercise duration was 45 minutes, three times per week, at 75% of age-predicted maximum heart rate. Of 98 screened subjects, 65 subjects were enrolled and 49 completed the 12-week trial: 12 in the high-flavanol cocoa group (four males, eight females; mean age 45.3±4.4 years), 13 in the high-flavanol cocoa and exercise group (six males, seven females; mean age 45.5±4.0 years), 11 in the low-flavanol cocoa group (three males, eight females, mean age 44.4±4.4 years) and 13 in the low-flavanol cocoa and exercise group (four males, nine females, mean age 45.2±3.0 years). Compared to the low-flavanol cocoa, high-flavanol cocoa increased flow-mediated dilatation acutely (two-hour post-dose) by 2.4% ($P<0.01$) and chronically (over 12 weeks) by 1.6% ($P<0.01$), and reduced insulin resistance by 0.31% ($P<0.05$), DBP by 1.6mmHg ($P<0.05$) and mean arterial pressure (MAP) by 1.2mmHg ($P<0.05$), independent of exercise. Limitations include the small numbers of subjects in groups, and differences between groups.

Farouque et al, 2006 (neutral) This was an RCT conducted in Australia to determine the acute and chronic effects of flavanol-rich cocoa on endothelial and vascular function in subjects with CAD. Subjects were randomized to receive either a flavanol-rich chocolate bar and cocoa beverage (444mg flavanols, 170mg epicatechin monomer) or matching isocaloric placebo (19.6mg flavanols, 4.7mg epicatechin monomer) daily for six weeks. Of 40 subjects initially enrolled (30 males, mean age 61±8 years), 38 subjects completed the trial. No acute or chronic changes in flow-mediated dilatation or systemic arterial compliance were seen in either group, and there were no differences in soluble cellular adhesion molecules or forearm blood flow responses to ischemia, exercise, acetylcholine chloride or sodium nitroprusside. Limitations include the relatively short intervention duration and baseline differences between groups; authors note that the age of the subjects and their burden of cardiovascular risk factors may have been too great for flavanol-rich cocoa to exert a positive effect over the time frame of the study.

Janszky et al, 2009 (neutral) This was a population-based, case-control study conducted in Sweden, to assess the long-term effects of chocolate consumption in patients with established CHD in the Stockholm Heart Epidemiology Program (SHEEP). Male cases were identified during 1992 and 1993 and female cases during 1992 and 1994. Questionnaires about chocolate consumption were completed a few days after the acute MI and patients underwent a health examination three months after discharge; patients were followed for eight years. Of 1,381 identified, 1,169 subjects aged 45 to 70 years were included in the analysis. Chocolate consumption had a strong inverse association with cardiac mortality; when compared to those never eating chocolate, the multivariable-adjusted hazard ratios were 0.73 (95% CI: 0.41 to 1.31) for those consuming chocolate less than once per month, 0.56 (95% CI: 0.32 to 0.99) for those consuming chocolate up to once per week and 0.34 (95% CI: 0.17 to 0.70) for those consuming chocolate twice or more per week. There was an inverse but weak association between chocolate consumption and total mortality. Authors note that it is possible that some patients ceased chocolate consumption prior to hospitalization due to poor health, and that patients were not queried regarding dark vs. milk chocolate.

Kurlandsky and Stote, 2006 (neutral) This was an RCT conducted in the US to evaluate the cardioprotective effects of chocolate and almond consumption in healthy women. Subjects were randomized to one of four interventions for six weeks: 41 g dark chocolate per day, 60g almonds per day, both 41g dark chocolate and 60g almonds per day or a control diet without nuts and chocolate; all subjects consumed a self-selected diet based on the National Cholesterol Education Program (NCEP) Therapeutic Lifestyle Changes (TLC). Of 52 women (mean age 43.7 years) initially enrolled, 47 completed the trial. During the study period, all subjects improved dietary intakes and no subjects gained or lost weight. While serum cholesterol concentrations did not change during the study period, triacylglycerol levels were reduced by 21% in the chocolate group, 13% in the almond group, 19% in the chocolate and almond group and 11% in the control group ($P<0.05$). In addition, circulating intercellular adhesion molecule (ICAM) levels decreased by 10% in the chocolate group ($P=0.027$). No significant changes were observed in any group for vascular

adhesion molecule and high-sensitivity C-reactive protein (CRP) levels. Limitations include small numbers of subjects in groups and baseline differences between groups; only women were studied.

Monagas et al, 2009 (neutral) This was a randomized crossover trial conducted in Spain to evaluate the effects of chronic cocoa consumption on cellular and serum biomarkers related to atherosclerosis in high-risk patients. All participants followed an isocaloric Mediterranean-type diet throughout the study period; for four weeks, subjects were randomized to consume either 40 g cocoa powder with 500ml skim milk per day or only 500ml skim milk per day, and then consumed the opposite diet for an additional four weeks. Of 47 subjects initially enrolled, 42 completed the study (19 men, 23 women; mean age, 69.7±11.5 years). There were NS changes in the expression of adhesion molecules on T-lymphocyte surfaces between groups. However, in monocytes, the expression of VLA-4 (P=0.005), CD40 (P=0.028) and CD36 (P=0.001) was significantly lower after cocoa powder and milk intake compared with milk intake alone. In addition, serum concentrations of P-selectin and intercellular adhesion molecule-1 were significantly lower (both P=0.007) after cocoa powder and milk intake compared with milk intake alone. Limitations include the short intervention duration and the lack of washout period between interventions.

Taubert, 2007 (neutral) This was an RCT conducted in Germany to assess the effect of consumption of cocoa on BP reduction, as well as plasma markers of vasodilative nitric oxide (S-nitrosoglutathione) and oxidative stress (8-isoprostane). Older subjects (56 to 73 years) with PHTN or stage 1 hypertension (24 women, 20 men) were assigned to a receive either 6.3g per day of commercially available polyphenol-rich dark chocolate containing 3.1g of cacao (30mg polyphenols and 30 Cal) for 18 weeks or a matching 5.6g per day of polyphenol-free white chocolate. Subjects in the dark chocolate group had a significant decrease in mean SBP at 18 weeks; however, those in the white chocolate group did not. From baseline to 18 weeks, dark chocolate intake reduced mean SBP by −2.9 (1.6) mmHg (P<0.001) and DBP by −1.9 (1.0)mmHg (P<0.001) without changes in weight gain, plasma lipids, glucose, or 8-isoprostane. Hypertension prevalence declined from 86% to 68% and there was an increase in S-nitrosoglutathione by 0.23nmol per L (P<0.001) in the dark chocolate group. White chocolate consumption did not cause any change in BP or plasma biomarkers.

View table in new window

Author, Year, Study Design, Class, Rating	Study Description, Duration	Study Population, Demographics	Intervention	Significant Outcomes	Limitations
Allen et al 2008 Study Design: Randomized Crossover Trial Class: A Rating: 	Examined the effect of daily consumption of a flavanol-containing chocolate bar with added phytosterols on CVD risk factors. Four weeks, with two-week lead-in.	Normotensive population with elevated cholesterol. Out of 650 recruited subjects, 49 entered the study and 44 subjects completed the study. • 24 initially received the phytosterol-containing bars (66% male, mean age 45.9±8.1 years). • 20 initially received the control bars (64% male, mean age 43.5±8.9 years). Location: United States.	After a two-week lead-in diet based on the AHA "An Eating Plan for Healthy Americans," subjects consumed two cocoa flavanol-containing dark chocolate bars per day, with or without 1.1g sterol esters per bar, for a period of four weeks and then were switched to the other chocolate bar for an additional four weeks.	Regular consumption of the phytosterol-containing chocolate bars resulted in ↓ of 2.0% in serum TC and 5.3% in LDL-C (both P<0.05). Consumption of cocoa flavanols reduced SBP after eight weeks (-5.8mmHg, P<0.05).	Studies varied in sample sizes and infant ages.
Baba et al 2007 Study Design: Randomized Controlled Trial Class: A Rating: 	Tested whether long-term intake of cocoa powder altered plasma lipid profiles. 12-week diet periods.	25 normocholesterolemic and mildly hypercholesterolemic male subjects completed the trial. Mean age: 38±1 years. Location: Japan.	Subjects randomized to consume either 12g sugar a day (control group) or 26g cocoa powder and 12g sugar a day (cocoa group) for 12 weeks.	Plasma HDL-C was significantly ↑ in the cocoa group compared with the control group (24% vs. 5%, P<0.05). The prolongation from baseline levels in the lag time of LDL oxidation in the cocoa group was significantly > the ↓ measured in the control group (9% vs. -13%, P<0.05).	Relatively small sample size. DHA supplement did not affect maternal DHA levels in previous trial.
Buijsse B, Feskens EJM et al, 2006 Study Design: Cohort study Class: B	To determine whether habitual cocoa intake was inversely related to BP and CVD mortality. 15-year follow-up.	Elderly male participants from the Zutphen Elderly Study. Out of 876 men with dietary intake estimations, chronic disease prevalence was available for 790 men; 470 were included in	Cocoa intake was estimated in 1985, 1990 and 1995 by cross-check dietary history; causes of death ascertained during 15-year follow-up.	During the 15-year follow-up, 314 men died (66.8%), 152 from CVD. Median cocoa intake was 2.11g per day in 1985, 2.30g per day in 1990 and 2.36g per day in 1995.	None.

Rating:		analysis. Age at baseline: 65 to 84 years.		After multivariate adjustment, compared to the lowest tertile of cocoa intake, the mean systolic SBP in the highest tertile of cocoa intake was 3.7mmHg ↓ (95% CI: -7.1 to -0.3mmHg, P=0.03) and the mean DBP was 2.1mmHg ↓ (95% CI: -4.0 to -0.2mmHg, P=0.03). Compared with the lowest tertile cocoa intake, the adjusted RR for men in the highest tertile of cocoa intake was 0.50 (95% CI: 0.32 to 0.78, P=0.004) for cardiovascular mortality and 0.53 (95% CI: 0.39 to 0.72, P<0.001) for all-cause mortality.	
Crews, Harrison and Wright 2008 Study Design: Randomized Controlled Trial Class: A Rating:	Examined the short-term effects of dark chocolate and cocoa on variables associated with neuropsychological functioning and cardiovascular health. Six-week diet period.	Healthy, cognitively intact older adults. Of 101 subjects aged 60 years or older initially randomized, 90 completed the trial (38 males and 52 females), 45 in each group. Location: United States.	Participants were randomly assigned to receive a 37g dark chocolate bar and 237ml of an artificially sweetened cocoa beverage, or similar placebo products, each day for six weeks.	NS group-by-trial interactions were found for any of the neuropsychological variables, hematologic tests or BP variables examined. However, the mean pulse rate after three and six weeks of treatment was significantly higher in the dark chocolate and cocoa group than at baseline (P<0.01) and when compared with the placebo group at three and six weeks (P<0.01).	Maternal report of child development and behavior are prone to reporting bias. Disproportionate attrition of socially disadvantaged subjects.
Davison et al 2008 Study Design: Randomized Controlled Trial Class: A Rating:	Investigated the effect of cocoa flavanols and exercise on cardiometabolic risk factors. 12-week diet period.	Overweight and obese subjects. Of 98 screened subjects, 65 subjects were enrolled and 49 completed the 12-week trial: • 12 in the high-flavanol cocoa group (four males, eight females; mean age 45.3±4.4 years) • 13 in the high-flavanol cocoa + exercise group (six males, seven females; mean age 45.5±4.0 years) • 11 in the low-flavanol cocoa group (three males, eight females; mean age 44.4±4.4 years) • 13 in the low-flavanol cocoa + exercise group (four males, nine females; mean age 45.2±3.0 years). Location: Australia.	Subjects were randomized to one of four groups for 12 weeks: • High-flavanol cocoa (902mg flavanols) • High-flavanol cocoa and exercise • Low-flavanol cocoa (36mg flavanols) • Low-flavanol cocoa and exercise.* *Exercise duration was 45 minutes, three times per week, at 75% of age-predicted maximum heart rate.	Compared to the low-flavanol cocoa, high-flavanol cocoa ↑ flow-mediated dilatation acutely (two hours post-dose) by 2.4% (P<0.01) and chronically (over 12 weeks) by 1.6% (P<0.01) and ↓ insulin resistance by 0.31% (P<0.05), DBP by 1.6mmHg (P<0.05) and MAP by 1.2mmHg (P<0.05), independent of exercise.	Small sample size and dropout of subjects throughout the study. Measurements not made in all subjects at all time points.

Desch S, Schmidt J et al, 2010 Study Design: Meta-analysis or Systematic Review Class: M Rating:		MEDLINE publications from 1966 to 2009, EMBASE, Central Cochrane and ClinicalTrials.gov. Examined association between dark chocolate and cocoa-containing beverages on arterial BP.	10 RCTs with 297 subjects. Subjects were either healthy adults or patients with PHTN or stage 1 HTN. Treatment duration was two to 18 weeks. Meta-analysis of cocoa product intake and change in SDP and DBP.	Mean BP Δ across trials: SBP: -4.5mmHg (95% CI: -5.9 to -3.2, P<0.001). DBP: -2.5mmHg (95% CI: -3.9 to -1.2 P<0.001). Meta-analysis showed BP-lowering effects of cocoa-rich products.	None.
Ding EL, Hutfless SM et al, 2006 Study Design: Meta-analysis or Systematic Review Class: M Rating:		MEDLINE publications from 1966 to 2005 reviewed for experimental, observational and clinical studies. Examined association between cocoa, cacao, chocolate, stearic acid, flavonoids and risk of CVD.	21 RCTs measured intermediate markers of CVD risk. 11 prospective cohort studies examined CVD outcomes. Updated meta-analysis on flavonoid intake and CHD mortality.	RCTs showed that cocoa and chocolate have beneficial effects on BP, inflammatory markers, anti-platelet function, serum HDL and LDL oxidation. Prospective cohort studies showed that flavonoids in chocolate were positively associated with ↓ risk of CVD mortality. RCTs that examined stearic acid showed it had no effect on serum cholesterol and lipoprotein levels.	Study population contained a high proportion of women who were educated, white and from a higher socioeconomic class.
Farouque et al 2006 Study Design: Randomized Controlled Trial Class: A Rating:	To determine the acute and chronic effects of flavanol-rich cocoa on endothelial and vascular function. Six-week diet period.	Subjects with CAD. Of 40 subjects initially enrolled (30 males, mean age 61±8 years), 38 subjects completed the trial. Location: Australia.	Subjects were randomized to receive either a flavanol-rich chocolate bar and cocoa beverage (444mg flavanols, 170mg epicatechin monomer) or matching isocaloric placebo (19.6mg flavanols, 4.7mg epicatechin monomer) daily for six weeks.	No acute or chronic Δ in flow-mediated dilatation or systemic arterial compliance were seen in either group, and there were no differences in soluble cellular adhesion molecules or forearm blood flow responses to ischemia, exercise, acetylcholine chloride or sodium nitroprusside.	Subjects were not a representative sample; women included in data analysis differed from those not included with respect to breastfeeding duration, marital status and smoking during pregnancy.
Hooper L, Kroon PA et al, 2008 Study Design: Meta-analysis or Systematic Review Class: M Rating:		MEDLINE, EMBASE, Cochrane Library to June 2007 publications. Examined association between flavonoid-rich foods and CVD risk.	Six RCTs used for meta-analysis of effects of chocolate or cocoa on %FMD.	Chocolate ↑ FMD: • ↑ 3.99% after acute intake (95% CI: 2.86% to 5.12%) • ↑ 1.45% after chronic intake (95% CI: 0.62% to 2.28%). Time-course showed peak effect at two hours. No strong epicatechin dose effect.	None.

Janszky et al 2009 Study Design: Population-based Case-Control Study Class: C Rating:	To assess the long-term effects of chocolate consumption. Eight-year follow-up.	Patients with established CHD in the Stockholm Heart Epidemiology Program (SHEEP). Male cases were identified during 1992 and 1993 and female cases during 1992 and 1994. Of 1,381 identified, 1,169 subjects aged 45 to 70 years were included in the analysis. Location: Sweden.	Questionnaires about chocolate consumption were completed a few days after acute MI. Patients underwent health examination three months after discharge. Patients followed for eight years.	Chocolate consumption had strong inverse association with cardiac mortality; when compared to those never eating chocolate, the multivariable-adjusted HRs were 0.73 (95% CI: 0.41 to 1.31) for those consuming chocolate <one time a month, 0.56 (95% CI: 0.32 to 0.99) for those consuming chocolate up to one time a week and 0.34 (95% CI: 0.17 to 0.70) for those consuming chocolate ≥twice per week. There was an inverse, but weak association between chocolate consumption and total mortality.	Authors note that it is possible that some patients ceased chocolate consumption prior to hospitalization due to poor health, and that patients were not queried regarding dark vs. milk chocolate.
Kurlandsky and Stote, 2006 Study Design: Randomized controlled parallel trial. Class: A Rating:	Evaluated the cardioprotective effects of chocolate and almond consumption. Six-week diet period.	52 healthy women initially enrolled; 47 completed the trial. Mean age: 43.7 years. Location: United States.	Subjects randomized to one of four interventions for six weeks: 41g dark chocolate per day, 60g almonds per day, both 41g dark chocolate and 60g almonds per day, or a control diet without nuts and chocolate. All subjects consumed a self-selected diet based on the NCEP Therapeutic Lifestyle Changes.	During the study period, all subjects improved dietary intakes and no subjects gained or lost weight. No Δ in serum cholesterol concentrations during the study period. TG levels ↓ by 21% in chocolate group, 13% in almond group, 19% in chocolate and almond group and 11% in control group (P<0.05). Circulating intercellular adhesion molecule (ICAM) levels ↓ by 10% in the chocolate group (P=0.027). NS Δ observed in any group for vascular adhesion molecule and high-sensitivity CRP levels.	Limitations include small numbers of subjects in groups and baseline differences between groups; only women were studied.
Monagas et al 2009 Study Design: Randomized Crossover Trial Class: A Rating:	To evaluate the effects of chronic cocoa consumption on cellular and serum biomarkers related to atherosclerosis. Four-week diet period.	High-risk patients. Of 47 subjects initially enrolled; 42 completed the study (19 men, 23 women). Mean age: 69.7±11.5 years. Location: Spain.	All participants followed an isocaloric Mediterranean-type diet throughout the study period For four weeks, subjects were randomized to consume either 40g cocoa powder with 500ml skim milk per day or only 500ml skim milk per day. Participants consumed the opposite diet for an additional four weeks.	NS Δ in expression of adhesion molecules on T-lymphocyte surfaces between groups. In monocytes, the expression of VLA-4 (P=0.005), CD40 (P=0.028) and CD36 (P=0.001) was significantly ↓ after cocoa powder and milk intake, compared with milk intake alone. P-selectin and intercellular adhesion molecule-1 were significantly ↓ (both P=0.007) after cocoa powder and milk intake, compared with milk intake alone.	Lack of washout period between interventions.

Taubert D, Roesen R et al, 2007 Study Design: Randomized controlled parallel-group trial Class: A Rating:	To assess the effect of cocoa consumption on BP, plasma markers of vasodilation and oxidative stress. 18-week diet period.	Older subjects with pre- or stage 1 HTN (24 women, 20 men) Age: 56 to 73 years. Location: Germany.	Subjects were assigned to dark chocolate group (6.3g per day polyphenol-rich dark chocolate with 3.1g cacao (30mg polyphenols) for 18 weeks or matching polyphenol-free white chocolate group.	Dark chocolate group had significant ↓ in mean SBP at 18 weeks; white chocolate group did not. Dark chocolate intake ↓ mean SBP by -2.9 (1.6)mmHg (P<0.001) and DBP by -1.9 (1.0)mmHg (P<0.001). No Δ in weight gain, plasma lipids, glucose, or 8-isoprostane in dark chocolate group. HTN prevalence ↓ from 86% to 68% and S-nitrosoglutathione ↑ by 0.23nmol per L (P<0.001) in dark chocolate group. White chocolate consumption did not cause any Δ in BP or plasma biomarkers.	None.

Research Design and Implementation Rating Summary
For a summary of the Research Design and Implementation Rating results, click here.

Worksheets

Allen RR, Carson L, Kwik-Uribe C, Evans EM, Erdman JW Jr. Daily consumption of a dark chocolate containing flavanols and added sterol esters affects cardiovascular risk factors in a normotensive population with elevated cholesterol. *J Nutr.* 2008 Apr;138(4):725-31.

Baba S, Osakabe N, Kato Y, Natsume M, Yasuda A, Kido T, Fukuda K, Muto Y, Kondo K. Continuous intake of polyphenolic compounds containing cocoa powder reduces LDL oxidative susceptibility and has beneficial effects on plasma HDL-cholesterol concentrations in humans. *Am J Clin Nutr.* 2007 Mar;85(3):709-17.

Buijsse B, Feskens EJM, Kok FJ, Kromhout D. Cocoa intake, blood pressure and cardiovascular mortality: the Zutphen Elderly Study. Arch Intern Med. 2006; 166 (4): 411-417.

Crews WD Jr, Harrison DW, Wright JW. A double-blind, placebo-controlled, randomized trial of the effects of dark chocolate and cocoa on variables associated with neuropsychological functioning and cardiovascular health: clinical findings from a sample of healthy, cognitively intact older adults. *Am J Clin Nutr.* 2008 Apr;87(4):872-80.

Davison K, Coates AM, Buckley JD, Howe PR. Effect of cocoa flavanols and exercise on cardiometabolic risk factors in overweight and obese subjects. *Int J Obes (Lond).* 2008 Aug;32(8):1289-96. Epub 2008 May 27.

Desch S, Schmidt J, Kobler D, Sonnabend M, Eitel I, Sareban M, Rahimi K, Schuler G, Thiele H. Effect of cocoa products on blood pressure: systematic review and meta-analysis. *Am J Hypertens.* 2010 Jan; 23(1): 97-103.

Ding EL, Hutfless SM, Ding X, Girotra S. Chocolate and prevention of cardiovascular disease: A systematic review. *Nutr Metab (Lond).* 2006 Jan 3; 3: 2.

Farouque HM, Leung M, Hope SA, Baldi M, Schechter C, Cameron JD, Meredith IT. Acute and chronic effects of flavanol-rich cocoa on vascular function in subjects with coronary artery disease: a randomized double-blind placebo-controlled study. *Clin Sci (Lond).* 2006 Jul;111(1):71-80.

Hooper L, Kroon PA, Rimm EB, Cohn JS, Harvey I, Le Cornu KA, Ryder JJ, Hall WL, Cassidy A. Flavonoids, flavonoid-rich foods, and cardiovascular risk: A meta-analysis of randomized controlled trials. *Am J Clin Nutr.* 2008 Jul; 88(1): 38-50.

Janszky I, Mukamal KJ, Ljung R, Ahnve S, Ahlbom A, Hallqvist J. Chocolate consumption and mortality following a first acute myocardial infarction: the Stockholm Heart Epidemiology Program. *J Intern Med.* 2009 Sep;266(3):248-57.

Kurlandsky S, Stote K. Cardioprotective effects of chocolate and almond consumption in healthy women. *Nutrition Research*. 2006; 26(10): 509-516.

Monagas M, Khan N, Andres-Lacueva C, Casas R, Urpí-Sardà M, Llorach R, Lamuela-Raventós RM, Estruch R. Effect of cocoa powder on the modulation of inflammatory biomarkers in patients at high risk of cardiovascular disease. *Am J Clin Nutr.* 2009 Sep 23. [Epub ahead of print]

Taubert D, Roesen R, Lehmann C, Jung N, Schomig E. Effects of low habitual cocoa intake on blood pressure and bioactive nitric oxide: A randomized controlled trial. *JAMA* 2007; 298(1): 49–60.